

Evaluation of e-prime with cardiac magnetic resonance cine imaging—preliminary feasibility study with comparison to echocardiography

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Synopsis

Diastolic dysfunction is commonly assessed by echocardiography, but not by cardiovascular magnetic resonance (CMR). To evaluate diastolic function, the mitral annular flow (E) and velocity (e') at the early rapid filling phase are measured. While E can be accurately measured by CMR, methods for measuring e' need to be established. In this study a feature tracking based method for measuring e' is applied to CMR images, and validated against echocardiography. There was an agreement between the methods, but sources of disparities between CMR and echocardiographic e' measurements need to be further studied in order to improve the accuracy of e' measurement by CMR.

Introduction

Diastolic dysfunction is the underlying cause in 40-50% of patients suffering from heart failure¹. Clinically, diastolic dysfunction is assessed by transthoracic echocardiography (TTE), by measuring the mitral annular flow (E) and velocity (e') at the early rapid filling phase. E/e' is a surrogate for left ventricular filling pressure² and has important implications for left atrial remodeling. Cardiovascular magnetic resonance (CMR) is not clinically utilized to measure e', although it is feasible using tissue phase mapping³ or feature tracking algorithms⁴. While markers of diastolic function 'E' and 'A' can be accurately measured by phase contrast CMR¹, without e' their value is limited. The aim of this work was to show preliminary results of e' measurements from long-axis 4-chamber CMR cine images using a semi-automatic feature tracking algorithm, validated against TTE.

Methods

Thirty-five patients (13 female, age 49±16 years) underwent CMR on a 1.5T clinical scanner (Siemens Healthcare, Erlangen), as well as TTE. Patients were retrospectively included for diverse indications including dilated cardiomyopathy, hypertrophic cardiomyopathy, sarcoid, arrhythmogenic right ventricular cardiomyopathy, coronary disease and family history of disease. Patients with arrhythmia during the scan were excluded. CMR images were acquired with a balanced steady-state-free-precession (bSSFP) sequence with 30 timeframes per cardiac cycle, 2x2x8mm³, TR/TE/θ=3ms/1.5m/60°. Heart-rate during CMR was 70±11 bpm (mean±SD). The software Segment⁵ was used to assess e', using a time-resolved feature tracking of the mitral annulus displacement with manual corrections when necessary⁴, see Figure 1. The lateral and septal displacement curves were smoothed to eliminate discontinuities, and the velocity was calculated by taking the time derivative. The peak velocity at the early rapid filling phase was considered e' in the CMR images.

Results

Figure 2 discloses the agreement between e' by TTE and CMR. Correlation R values were strong (R=0.76 in septal point, R=0.75 in lateral point). Bland-Altman analysis yielded a low bias but rather large standard deviation (bias±2SD = 0.63±4.0 cm/s for septal e', and 1.1±5.6 cm/s for lateral e'). Neither increased heart rate nor days between measurements by TTE and CMR were factors in the observed differences between the e' measures.

Conclusions

This preliminary study presents and validates a new CMR-based method for measuring e' , which could potentially enable assessment of diastolic function using CMR. Although there was a strong correspondence, it will be important to identify the sources of disparities between CMR and echocardiographic e' measurement, in order to improve the accuracy of e' measurement by CMR.

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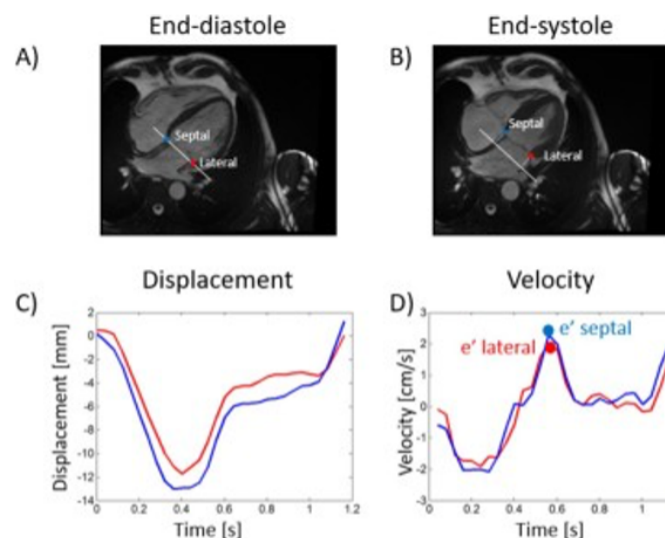


Figure 1. Illustration of calculation of e' from CMR imaging. (A) The septal (blue) and lateral (red) mitral annular points were manually indicated in the end diastolic timeframe, which also defines the mitral annular plane (white). Tracking of the points yield the displacement relative to the end diastolic annular plane, shown in (B) for the end-systole. (C) The resultant displacement curves for both points, septal in blue and lateral in red. (D) Velocity curves for both points, with the peak velocity (e') indicated.

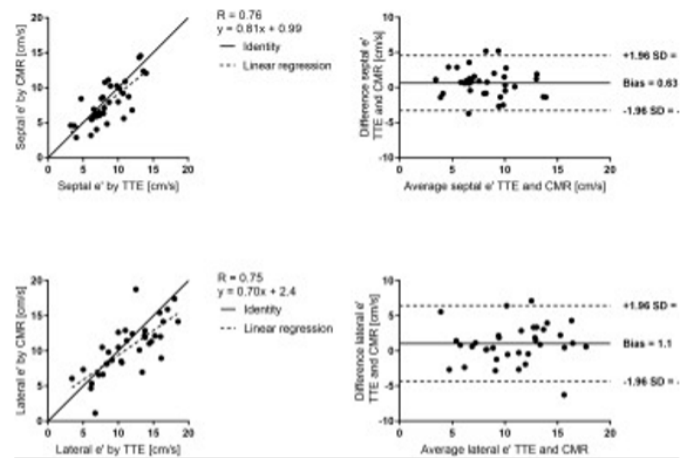


Figure 2. Left panel shows scatter plots between e' measured by TTE and CMR. Right panel shows corresponding Bland-Altman plots. Top row shows results for septal e' and bottom row for lateral e'.